

PLAN OF STUDY

INTERIM SURVEY REPORT  
FOR  
FLOOD CONTROL  
AND ALLIED PURPOSES

LOWER SANTA CRUZ RIVER,  
ARIZONA

AUGUST 1977

U S ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT

#### Footnotes

1. Los Angeles District Corps of Engineers: Flood Damage Report on Storm and Flood of 26-30 September 1962-Santa Cruz River and Santa Rosa Wash, Southern Arizona, November 1963.
2. Ibid., p. 19
3. Los Angeles District Corps of Engineers: Interim Report on Survey for Flood Control-Santa Rosa Wash, Arizona, August 1963, p. 24
4. Los Angeles District Corps of Engineers: Flood Damage Report on Storm and Flood of 9-11 September 1964-Upper Santa Cruz River, Southern Arizona, December 1964
5. Ibid., p. 18
6. Arizona Water Commission: Phase I-Arizona State Water Plan-Inventory of Resource and Uses, July 1975, p. 112. Normalized 1970 conditions-the Lower Santa Cruz Basin as defined by the A.W.S. is of much greater area than the "study area" as defined for this study.
7. H. H. Schuman for U.S. Geological Survey: "Map I-845-H Land Subsidence and Earth Fissures in Alluvial Deposits in the Phoenix Area, Arizona" 1974.
8. Army Corps of Engineers: Engineering Manual 110-2-1902, 1 April 1970.
9. N. Ackerly and A. Rieger: An Archeological Overview of Southwest Pinal County, Arizona, Arizona State Museum, November 1976
10. Arizona Crop and Livestock Service: 1976 Arizona Agricultural Statistics, March 1977, p. 6, 7
11. Ibid., p. 50
12. Arizona Outdoor Recreation Coordinating Commission: State of Arizona Statewide Comprehensive Outdoor Recreation Plan, 1972, p. 3
13. Ibid., p. 9
14. Army Corps of Engineers: Engineering Regulation 1105-2-220



<b>STUDY COST ESTIMATE (PB-6)</b>		APPROPRIATION TITLE: <b>General Investigations</b>			NAME OF STUDY	
		96x3121			Gila River & Tributaries	
		APPROPRIATION CATEGORY <b>Surveys</b>			Interim for Lower Santa Cruz River	
		APPROPRIATION CLASS <b>Flood Damage Prevention Studies</b>			LOCATION <b>Arizona and New Mexico</b>	
LINE NO.	UNIFORM COST CLASSIFICATION	FEATURE	CURRENT COST ESTIMATE	PREVIOUS COST ESTIMATE	REMARKS	
(1)	(2)	(3)	(4)	(5)		
1	502.01	Preliminary Planning and Public Contacts	\$ 93,300			
2	.02	Hydrology Studies	51,800			
3	.03	Survey and Mapping	3,700			
4	.04	Foundations and Material Investigations	16,400			
5	.05	Stream Regulation Studies	- 0 -			
6	.06	Design and Cost Studies	88,100			
7	.07	Economic Studies	40,900			
8	.08	Real Estate Studies	5,200			
9	.09	Special Studies*	120,200		*Includes:	
10	.10	Preparation of Reports	149,700		a. Economic Base Studies \$24,200	
11	.11	Supervision and Administration	130,700		b. Environmental Studies 36,700	
12		Total	\$700,000		c. Fish and Wildlife	
13					Contract 7,500	
14					d. Water Rights	
15					Investigation 12,000	
16					e. Recreation 26,100	
					f. Groundwater Studies 7,500	
					g. Archeological Studies 6,200	
DATE PREPARED		DIVISION	DISTRICT	REGION	BASIN	PAGE 1 OF 1
5 Aug 1977		South Pacific	Los Angeles	Lower Colorado	South Coastal	

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SUMMARY

The lower Santa Cruz River Basin, one of the most productive agricultural areas in Arizona, is currently undergoing pressure to develop to urban uses due to its strategic location between the Cities of Phoenix and Tucson. Long a concern of local residents, flood problems along the lower Santa Cruz River are being accentuated by this urban pressure.

Large floods have occurred in the Santa Cruz Basin in the past; the most damaging was the flood of 26-30 September 1962. Total damages in the lower Santa Cruz basin were estimated at \$7,960,000. Since then, floods have occurred in 1964, 1965, 1966, and 1967.

A public meeting to initiate this study was held in Casa Grande, Arizona on June 16, 1976. Representatives of the Maricopa, Stanfield, Midway, and Greene Reservoir Flood Control Districts and communities in the lower Santa Cruz area as well as local residents emphasized the need for flood control and suggested a plan for diversion of Santa Cruz floodflows to Tat Momolikot Dam on Santa Rosa Wash. Representatives of the Arizona Wildlife Federation, the Audubon Society, and the Sierra Club have objected in principle to flood control works, including a possible diversion.

Planning objectives for this study are the water and related land resource needs specific to the lower Santa Cruz area which can be addressed to enhance national economic development and environmental quality. This study will consider and evaluate alternative structural and nonstructural methods of flood plain management as well as other, related, management measures along the lower Santa Cruz River.

Alternative plans will be formulated to address the planning objectives. Each alternative will be analyzed to determine potential impacts. Recommendations will be made based on an evaluation of each plan's contributions to the National Economic Development, Environmental Quality, Regional Development, and Social Well-Being Accounts of Principles and Standards, as well as other criteria including acceptability, completeness, effectiveness, and efficiency.

The total cost of the study is estimated to be \$700,000.

Stage 1 of the study, which covers previous activities dating from study initiation to submission of the Plan of Study, cost \$90,000. Accordingly, 610,000 is required to complete stages 2 and 3 of the Interim Survey Report.

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AUTHORIZATION

The study for flood control along the Lower Santa Cruz River was authorized under Section 6 of the Flood Control Act of June 28, 1938, which authorized and directed the Secretary of the Army to cause surveys for flood control of the Gila River and its tributaries in Arizona and New Mexico.

In 1976, Congress funded an interim study for the lower Santa Cruz River portion of the Gila River drainage basin.

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1.	Footnotes
2.	Study Schedule
3.	Study Cost Estimate (PB-6)
4.	Bibliography

## I-PROBLEM IDENTIFICATION

### Identifying Public Concerns

**GENERAL WATER-RELATED ISSUES.** For many years water-related issues have caused concern among people in the lower Santa Cruz River region. During the recent past, however, some of these issues have become more critical as problem effects accumulate and population increases. Primary concerns include the reduction of flood damages and the prudent use and conservation of water and related land resources.

**HISTORIC FLOODS.** Historic accounts indicate that many damaging floods have occurred in the Santa Cruz River Basin and its tributaries. Sizeable floods in this region occurred in 1886, 1890, 1891, 1906, 1914, 1916, 1921, 1926, 1929, 1940, 1941, 1945, 1950, 1953, 1955, 1961, 1962, 1964, 1965, 1966, and 1967. In recent times the most damaging and second most damaging floods in the lower Santa Cruz area were those of September 1962 and September 1964 respectively.

**1962 FLOOD AND DAMAGES.**<sup>1</sup> Peak flows for the flood of September 26-30, 1962 were estimated at 53,000 cubic feet per second (cfs) on the Santa Rosa Wash upstream of its confluence with the Santa Cruz River; 17,000 cfs along Green's Wash at Chuichu; and 24,100 cfs along Green's Canal downstream of its point of diversion from the Santa Cruz mainstem. Plate No. 2 shows these peak discharges and the estimated overflow area for this flood. Total damages for the area downstream of the Tat Momolikot Dam (completed in 1974 by the Corps of Engineers) caused by Santa Rosa Wash flows and downstream of the Greene Canal diversion caused by Santa Cruz River mainstem flows were estimated to be \$7,960,000.<sup>2</sup> Had the dam been in place in 1962, \$2,225,000 of these damages were estimated to have been preventable.<sup>3</sup>

**1964 FLOOD AND DAMAGES.**<sup>4</sup> The flood of September 9-11, 1964 was smaller than the 1962 flood. Much of the damage in Pinal County was along the Santa Cruz River mainstem upstream of Greene's Canal, along Greene's Canal, and along Greene's Wash downstream of Greene's Canal. Damages, mainly to agriculture, amounted to \$520,000.<sup>5</sup>

**OTHER RECENT FLOODS.** Floods of lesser magnitude occurred in August 1964, December 1965, January 1966, and December 1967. These floods caused damages to local protection works and in some cases breached these works causing damages to agricultural properties.

Floods in the recent past have prompted the formation of flood control districts for the purpose of flood damage prevention. The Stanfield and Maricopa districts were formed in 1958; the Greene Reservoir district was formed in 1962; and the Midway district in 1967. These districts build and maintain levees and channels for flood protection. The resources of these districts, however, have been insufficient to provide a high level of flood protection.

WATER USE, DEPLETION, GROUND SUBSIDENCE AND FISSURES. In the past, the availability of ground water and low-cost fuel for pumping has made water availability less a constraint to land use and development than in many other parts of the arid Southwest. Three primary factors are changing or will change this situation in the near future:

- (1) Ground water levels are dropping rapidly.
- (2) Population in the area is increasing rapidly.
- (3) Energy costs will rise.

Though surface water was important to early, limited development in the study area, most water use in the area now is from ground water reservoirs. Pumping for decades, primarily for irrigated agriculture, has lowered water tables to the point that much of the study area has been designated a "critical ground water area" by the State of Arizona. The annual overdraft of 520,000 acre feet of ground water in the lower Santa Cruz Basin<sup>6</sup> has lowered water tables by more than a hundred feet over most of the developed part of the study area and by more than 300 feet in the vicinity south and west of Stanfield during the period 1940 to 1970.

Current rates of ground water table decline of up to 20 feet per year are not uncommon in the study area. This decline has resulted in pump lifts which are commonly 300 to 500 feet with lifts of over 600 feet in some areas.

Periodic nonavailability of surface water (both from the Gila River via the Florence-Casa Grande Canal as a part of the San Carlos Irrigation Project and from the Santa Cruz River) and increased costs for pumping ground water have contributed to the withdrawal of a significant amount of irrigation-developed land from irrigated use.

Additional problems related to ground water depletion have been ground subsidence and the occurrence of earth fissures. A U.S. Geological Study Map dated 1974 shows areas of greatest subsidence in the vicinity of Eloy and Stanfield (this study shows subsidence exceeding 7 feet in the Stanfield area; ongoing studies are expected to show continued subsidence in these areas). Fissures, caused by uneven settling of the earth, have aggravated erosion and disrupted utilities, roads and irrigation structures in the study area.

EROSION AND AGGRADATION. Rapid runoff in the study area and upstream has created erosion problems particularly along stream channels. According to the U.S. Department of Agriculture the most severe problems have occurred along McClellan Wash near Picacho and on Greene's Canal downstream of the point of diversion from the Santa Cruz River. Moderate stream bank erosion is occurring on Greene's Wash downstream of Stanfield. Stream aggradation occurs when sediment-bearing flows slow to the point where sediment will settle to a stream bottom. It is a particular problem along the Greene's Canal diversion where continual aggradation along the Canal necessitates periodic raising of the downstream bank to maintain existing flood protection levels.

ALTERATION OF NATURAL STREAMSIDE HABITAT. As one of the most productive and scarcest natural-habitat types in the study area, the presence of natural streamside or riparian habitat greatly increases diversity of species and overall productivity of the natural environment. Modern development has decreased the presence of such habitat by consumptive use and alteration of natural water resources. Use of surface runoff in the study area and upstream by diversion to croplands and other uses and lowering of ground water tables has made less water available for maintenance of natural habitat. Changes in land use have affected the water quality of runoff entering stream channels. This, too, has affected habitat. Several environmental groups have voiced their opposition to plans which adversely affect this valuable, natural streamside habitat.

#### Other Public Concerns

URBAN PRESSURE. Population growth in the Phoenix and Tucson metropolitan area has increased pressure to develop in areas farther from the central core of these cities. Casa Grande, the largest city in the lower Santa Cruz basin lies between these two cities, 49 miles from Phoenix and 67 miles from Tucson. Casa Grande's population increased by 27 percent during the decade between 1960 and 1970 and an additional 35 percent to 14,250 in 1976. Pinal County, the third most populous in the State following Maricopa and Pima, is expected to grow rapidly as a corridor between the two urban regions. This development will aggravate the traditional urbanization problems of increased infrastructure costs (police and fire protection, school and other social services, and utilities), increased pressure to develop agricultural lands due to speculation and higher property taxes, and increased pressure to encroach upon flood plains.

RECREATION. The demand for outdoor recreation facilities has increased with sharply increasing population in the study area. Supply of recreation opportunity, particularly for water-based activities has not kept pace with demand.

#### Defining the Study Area

The area of primary focus for this study will be the lower Santa Cruz River and environs, from Redrock to its confluence with the Gila River. Emphasis in this primary area will include the identification of water and related land resources problems and solutions to those problems. When the term "study area" is used in this Plan of Study, it will refer to this primary study area.

The area including the entire Santa Cruz River basin and the Gila River downstream of the Santa Cruz will also be studied. Upper Santa Cruz basin studies will include those required to identify upstream factors contributing

to downstream problems. The investigation will also, necessarily, include consideration of upstream storage of floodwaters. The downstream effects on the Gila River and environs of solutions proposed for the Santa Cruz basin must also be assessed as a part of a total evaluation.

Pinal County, located between the Standard Metropolitan Statistical Areas (SMSA) of Phoenix and Tucson (Maricopa and Pima Counties), will be considered the area of regional economic impact analysis.

Economic effects on the nation will also be evaluated.

### Describing the Base Condition

LOCATION AND GENERAL DESCRIPTION. The Santa Cruz River basin, a subbasin of the 58,200 square-mile Gila River basin, consists of 8,200 square miles in southern Arizona and 400 square miles in Mexico (see pl. 1). The drainage area is about 170 miles long and 50 miles wide. The Santa Cruz River, the main stream in the basin, begins at about 5,100 feet above sea level in Arizona, flows southward about 8 miles to the boundary of the United States and Mexico, makes a 35-mile loop into Sonora, Mexico, and reenters Arizona at a point about 6 miles east of Nogales. From there the river flows northward about 74 miles to Tucson; and then northwestward about 42 miles to its confluence with Greene Canal. The river continues to the northwest for a few miles before becoming indistinct. Beginning at its confluence with the Santa Cruz River, Greene Canal together with Greene Wash, Santa Rosa Wash, and the Santa Cruz River form a system of channelized streams about 75 miles long, carrying Santa Cruz flows to the Gila River.

GEOLOGY AND TOPOGRAPHY. Located within and typical of the Basin and Range Geomorphic Province, the primary study area consists of two, broad, alluvial-filled subbasins bounded discontinuously by low, rugged mountains and separated by the Casa Grande Ridge. This bedrock ridge trends north-south with the axis passing 3 miles west of the City of Casa Grande and is exposed as the Silver Reef, Sawtooth, and Tat Momoli Mountains to the south and the Sacaton Mountains to the north. The Casa Grande Mountains are an eastward extension of the ridge. The bedrock in the study area ranges in age from Precambrian to Quaternary and includes igneous, metamorphic, and sedimentary rock.

In the lower Santa Cruz basin the gently-sloping valley floor declines in elevation from about 1,800 feet above sea level in the southeast near Picacho Peak to about 1,150 feet northwest of Maricopa and is underlain by accumulations of alluvium ranging in texture from lacustrine silt and clay deposits to river-laid gravel and cobbles. The total alluvial thickness under the Santa Cruz River in the study area varies from 200 feet at the Casa Grande Ridge to at least 2,500 feet near Eloy in the center of the eastern subbasin. Alluvial thickness in the western subbasin is as great as 1,200 feet.



**SURFICIAL SOILS.** The alluvium is generally overlain by deep loamy soils with occasional depressional areas of saline-alkali soils. Slopes on the valley floor are usually less than 3 percent.

**GROUND WATER.** Because much of the Casa Grande Ridge is covered by about 200 feet of permeable sand and gravel, the lower Santa Cruz area has functioned as a continuous ground water basin as recently as 50 years ago with subsurface flow generally parallel to the Santa Cruz River flow-from southeast to northwest. Subsequent development of irrigation and municipal wells followed by decades of ground water withdrawal have produced cones of depression in the ground water table on either side of the ridge which disrupt natural, subsurface flow. Pumping has lowered the ground water table by as much as 400 feet in some areas. In 1974, the depth to ground water southwest of Casa Grande was 38 feet in the vicinity of the Casa Grande Ridge where the water is held high by shallow bedrock. Maximum depth to water northwest of Stanfield, is about 700 feet in a local cone of ground water table depression over 300 feet deep.

**SUBSIDENCE AND EARTH FISSURES.** Excessive ground water withdrawals have apparently resulted in earth subsidence and fissures in the Lower Santa Cruz area. Studies by the U.S. Geological Survey<sup>7</sup> show that there have been large areas of general subsidence in each of the two geologic subbasins. Earth fissures have appeared in these same areas disrupting drainageways, irrigation canals, and roads, and aggravating erosion. If ground water overdrafts continue as expected, these associated problems will also continue.

**SEISMICITY.** Severe earthquakes originating in California and Mexico have been noticed in Arizona, but only a few, weak earthquakes, magnitude less than 4 (Richter Scale), with epicenters in south-central Arizona have been recorded. There are no known Quaternary faults within 50 miles of the study area. For a distant earthquake (1934 Baja California M 7.1, Richter Scale), the maximum intensity felt in the study area was V on the Modified Mercalli Scale, as measured in Maricopa. An intensity of V is characterized by no structural damage although most people in the area could feel the earthquake. The study area is in zone 2 of seismic risk.<sup>8</sup>

**GENERAL CLIMATE.** The climate is typically desert in character, with short, mild winters and long, hot summers. High diurnal temperature variations are characteristic of the region. The prevailing winds are from the east and are usually light, although severe windstorms occur at rare intervals.

**PRECIPITATION AND STORMS.** A 30-year (1931-1960) mean annual precipitation over the Santa Cruz River basin ranges from about 10.75 inches in the vicinity of Tucson to 37.5 inches at the highest elevations of the Santa Rita Mountains. Heaviest precipitation occurs in the summer and winter seasons. Three types of storms produce precipitation in the Santa Cruz River basin-general winter storms, general summer storms, and local thunderstorms. A brief description of each storm type follows:

General winter storms usually occur during the period of December through March. They originate over the Pacific Ocean as a result of the interaction between polar Pacific and tropical Pacific airmasses and move eastward over the basin. These storms, which often last for several days, reflect orographic influences and are accompanied by widespread precipitation in the form of snow or rain.

General summer storms usually occur during the period of July through September. They are associated with an influx of tropical, maritime air originating over the Gulf of Mexico or the South Pacific Ocean and entering the area from a southeast or a southwest direction. Usually, the influx of tropical air is caused by circulation around a high-pressure area centered in southeastern United States, but occasionally it is caused by the remnants of a tropical hurricane. General summer storms are often accompanied by relatively heavy precipitation over large areas for periods of up to 24 hours, but showers may continue intermittently for as long as 3 days. The floods of September 1962 and September 1964, the most damaging to the study area of recent record were general summer storms, remnants of tropical hurricanes "Claudia" and "Tillie" respectively, originating in the Pacific Ocean.

Local thunderstorms can occur at any time of the year, either during general storms or as isolated phenomena. However, they are most common during the period of July through September when the basin is frequently covered by moist, unstable air originating over the Gulf of Mexico. These storms cover comparatively small areas and result in high-intensity precipitation of up to 3 hour duration.

**RUNOFF CHARACTERISTICS.** Little streamflow occurs except during and immediately following the heavier precipitation because climatic and drainage-area characteristics are not conducive to continuous runoff. Because of steep gradients, streamflow in the mountains increases rapidly in response to high-intensity precipitation and causes debris-laden flash floods on the valley plains below. When the floodwaters reach valley plains, they spread out overland. Flow velocities and peaks are reduced, debris is deposited, and a considerable amount of flow is lost to streambed infiltration. Vegetation has negligible effect on flood runoff, except where perennial grasses impede overland flow in the upper areas.

**SURFACE WATER QUALITY.** Section 208 of Public Law 92-500 requires that implementation plans be developed for reducing pollutants from all sources. The main thrust in the study area will be the control of nonpoint or diffused sources of pollution. Preparation of Section 208 plans for the study area is the responsibility of the Central Arizona Association of Governments (CAAG), the regional council of governments (COG). The Arizona Governor's office is responsible for insuring the adequacy of the 208 program. Fertilizers, pesticides, and animal wastes from feed lots present potential water quality hazards which will be addressed in the 208 program. Flood problems aggravate surface water quality problems.

GROUND WATER QUALITY. The quality of ground water is known to vary areally and vertically in ground water basins in the study area. Ground water overdraft and resulting lowered water tables in the study area has caused some deterioration in ground water quality. Ground water in the Stanfield-Maricopa area exhibited a 35 percent increase in average tds (390 mg/l to 526 mg/l) during the period 1941-1960, caused in part from the westward movement of highly mineralized water from the Casa Grande area into cones of depression in the Stanfield-Maricopa ground water basin. These cones of depression have been caused by ground water overdrafting.

NATURAL VEGETATION. The lower Santa Cruz basin lies within the Arizona Upland Desert, a subdesert of the wider region known as Sonoran Desert, and is characterized generally by a hot, dry climate interrupted by intense rains of short duration. The Sonoran Desert is the hottest of American southwestern deserts and richest in diversity of cacti. Natural vegetation in the lower Santa Cruz basin can be described in terms of the following three general plant associations:

Desert Wash Community. Desert wash vegetation occurs along small arroyos, washes, major drainageways, and slight depressions resulting from concentrated runoff. Desert riparian vegetation usually consists of trees such as ironwood, blue paloverde, mesquite, and desert willow; shrubs such as catclaw acacia, desert broom, and burrobrush; and various annual and perennial herbaceous vegetation and grasses. Also, some cottonwood occurs along major drainageways. Where a reticulate or braided drainage system occurs, desert wash species spread more uniformly over the alluvial plain. As water penetration is enhanced and evaporation is retarded, riparian vegetation develops over a large area rather than being confined to the drainage channel itself. As the upstream drainage area increases, there is usually a corresponding increase in the size and density of the riparian species present in a drainageway. Diversion of normal flows from the Santa Cruz mainstem to Greene's Wash via Greene's Canal has resulted in the establishment of a wash community along the diversion and some change in vegetation along the mainstem downstream from the diversion from wash to drier species. Channelization of Santa Cruz River tributaries has generally decreased the spatial extent of riparian vegetation in the study area.

Desert Outwash Plain Community. The outwash plain plant community, which covers much of the arid intermountain plains and lower bajada areas (lower parts of the broad alluvial fans extending from mountain bases into the basin) of this desert, usually consists of a sparse assemblage of shrubs and dwarf shrubs, annual and perennial herbs and grasses, and few trees. The outwash plain community grades from a nearly pure stand of creosote bush to the inclusion of bursages, cactus, and even desert riparian trees in the drainageways. Saltbush is often an important representative of this community. Irrigated agriculture and urban development have eliminated or altered much of the extensive desert outwash plant community that historically occurred in the study area.

Desert Upland Community. The desert upland or upper bajada plant community occurs outside areas subject to significant flooding. The upper vegetation is often a more dense continuation of the outwash plain or lower bajada community. Species characteristic of this community include creosote bush, bursages, barrel cactus, saguaro, ocotillo and various grasses. Various cholla cacti also occur, with staghorn and teddybear cholla being frequent representatives. Generally the upper bajada plant community has experienced the least disturbance of the natural habitats within the study area. Where disturbance has occurred, off-road vehicular use has caused most of the disruption and destruction of this plant community.

Natural vegetation is very limited in the intensively farmed areas but often includes some mesquite, creosote bush, desert broom, cottonwood, cattail, and Johnson grass along irrigation canals, ditches, and depressions or on idle agricultural land. A considerable acreage of agricultural land lies fallow and is being revegetated with such species as desert broom, bursage, goldenbush, creosote bush, mesquite, and various weedy annuals and perennial grasses.

WILDLIFE. In many places throughout the intensively farmed area, the riparian vegetation is the only significant remaining natural habitat for desert wildlife. The abundance and diversity of wildlife in the study area appears to result from the edge effect of adjacent agricultural and riparian habitats. Mourning doves, quail, various species of songbirds, roadrunners, hawks, lizards, rabbits, jackrabbits, ground squirrels, and coyotes are common inhabitants of riparian and agricultural edge habitats within the study area. Irrigated farmlands provide food and water for many species, especially doves and songbirds. Riparian habitat provides nesting and resting cover, food, and water (seasonally) for many species utilizing agricultural land and for the desert wildlife not benefiting from agricultural land uses. Mule deer, javelina, and bighorn sheep occur in the mountains and foothills within the regional study area.

THREATENED AND ENDANGERED SPECIES. The endangered peregrin falcon has been observed within the regional study area. The presence of any threatened or endangered plant species has not yet been determined.

ARCHEOLOGICAL, CULTURAL, AND HISTORICAL SETTING. Until recently, little has been known about the early Indian culture of the Papagueria, an area covering much of the northern Sonoran Desert. An archeological overview prepared by the Arizona State Museum as a part of planning studies for the Corps of Engineers<sup>9</sup> has reviewed other research on the general area and postulated a predictive model to aid in locating archeological sites in the study area. Review of existing studies has revealed little evidence of habitation prior to 700 A.D. though more extensive study will probably reveal it. Evidence of human habitation during later periods has been found and more is expected to be found in flood plain village sites and higher elevation hunting campsites in the study area. During these times, inhabitants were probably dependent alternately on flood plain agriculture or hunting and gathering in response to population pressures and the changing availability of water. More site-specific studies will be initiated as alternative plans are formulated.

Though the early explorers, Esteban, guide for Marcos de Nita, and Melchoir Diaz, traversed eastern Pinal County in the 16th century, the first European intruders of impact to central Pinal were the Spanish priests Eusebio Kino and Tomas Garces. Kino's influence on Indians in the San Pedro and Santa Cruz valleys was great, introducing elements of European agriculture to these areas. Early American influence on the area was exerted by trappers following the Gila River and later in the mid-1800's with the emergence of a trail generally following the Gila River as part of a major transcontinental route. In 1853, the study area entered the United States as a part of the Gadsden Purchase. Present-day Casa Grande was established in 1879, as Terminus, the temporary end of the Southern Pacific railway. Completion of the rail line opened up the study area to develop as a commercial center in support of settlement for agriculture.

Consistent with study objectives, identification of resources reflecting the heritage of this area will be a part of future studies.

GENERAL ECONOMICS AND LAND USE. Pinal County can be described in terms of two, distinct, physiographic/economic regions. The easterly mountain region has been and remains largely dependent on copper mining. Of interest to this study is the westerly half of the county. Once heavily dependent on irrigated agriculture, it has since developed a more diversified economic base. Contributing to this diversity is the relatively large amount of land in private and corporate ownership, particularly in the center of the study area along the Santa Cruz River and northward toward Coolidge and Florence. The Gila and Ak-Chin Indian Reservations occupy the northwest and the Papago the southwest corners of the study area with private and Bureau of Land Management lands between. State of Arizona lands occupy much of the eastern and southeastern parts of the study area.

Despite economic diversification in the study area, the primary base remains agriculture - crops and cattle. The western part of Pinal County accounts for most crop and cattle production in the second greatest agricultural production county in Arizona. The most important crop is cotton, occupying, on the average (over the period 1971-1975), 116,700 acres, more than 1/3 of all lands devoted to crops in Pinal County.<sup>10</sup> Other major crops include wheat, barley, safflower, hay, and fruits and vegetables. Pinal County is the largest producer of feeder cattle in the State averaging 234,000 head for the period 1971-1975.<sup>11</sup> Large feeder operations are located near Stanfield.

Pinal County produces more copper than any other county in Arizona, the greatest producing State in the Nation. Mining, the largest employer in the county, accounts for one of every three jobs in Pinal County (see table 1 below). Although much of that activity is located in eastern Pinal, recent mining developments in the western part of the county indicate a great impact on the study area. New operations by Hecla Company, 30 miles south of Casa Grande; Asarco, 3 miles northwest of Casa Grande, and Conoco near Florence are already major employers. Proposed expansion by these companies will directly affect study area economics during construction and operation phases by these companies and indirectly through increased demands for goods and services.



TABLE 1

## EMPLOYMENT IN PINAL COUNTY - JUNE 1976

<u>CLASSIFICATION</u>	<u>NUMBER EMPLOYED</u>
Agriculture	2,000
Mining	8,050
Manufacturing	2,600
Construction	775
Transportation and Public Utilities	600
Wholesale and Retail	3,225
Finance, Real Estate	475
Government	5,800
Services	2,275
All Other Non-farm	2,125
Adjustment for commuting and multiple jobholding	-2,000
Total employed	<u>25,925</u>

SOURCE: Arizona Department of Economic Security

The significant expansion of manufacturing in Pinal County, particularly in the study area, has been relatively recent. To support agriculture, firms process and supply livestock feeds, fertilizers and chemicals. Others process cotton and cottonseed into clothes and other products. There is also fabrication of farm machinery and storage structures. A major new development is the establishment of manufacturers of parts and materials to support the Phoenix market of manufacturers of high-technology products. The growth of the Phoenix economy has also resulted in the establishment of a diverse group of small manufacturers, characteristic of metropolitan fringe development. Mobile home manufacturers are an example of this. Attracted by efficient transport, proximity to Phoenix and Tucson, and pleasant climate, the manufacturing role should continue to expand in the study area economy.

On this diverse economic base, a large work force in transportation, utilities, construction, wholesale, retail, finance, real estate, government, and other services has grown to account for about one half of total employment within the county.

TRANSPORTATION AND UTILITIES. The lower Santa Cruz region is crossed by major transcontinental transportation and utility links. The area also has an adequate system of regional and local highways and roads. U.S. Interstate Highway 10, linking Los Angeles, California, with Jacksonville, Florida, (via Phoenix and Tucson, Arizona, El Paso, Texas, and New Orleans, Louisiana), passes through Casa Grande, the largest city in the study area. U.S. Interstate 8, originating in San Diego, California, terminates at I-10 near Casa Grande. The main east-west transcontinental route of the Southern Pacific Railway Company passes through Phoenix, Casa Grande, and Tucson. The El Paso natural gasline linking Texas gas fields with the West Coast also traverses the study area, and serves the area as a source of energy priced at interstate-regulated rates.

POPULATION. Pinal County, third most populous in the State after Maricopa (Phoenix) and Pima (Tucson), has been increasing in population at a rate comparable to Arizona as a whole, but significantly greater than that of the nation (see table 2 below). Casa Grande, the largest city in the study area and in the county has also grown at a slightly greater rate (35.3 percent over the period 1970-1976). In addition to growth of incorporated cities in the study area, significant subdivision of rural lands and subsequent development has added to population increases in the study area. Largest of these is Arizona City, an unincorporated community established in the early 1960's with a current population of about 1,300. Though lands in the study area have been subdivided at a rate much greater than that required for actual population increases, this subdivision is indicative of population growth expectations.

TABLE 2  
HISTORIC POPULATION COMPARISONS

	1950	1960	1970	1976	1970-1976 % Change
USA					
Arizona	749,587	1,302,161	1,772,482	2,270,000	28.1
Pinal County	43,191	62,673	68,579	86,800	26.6
Casa Grande	4,181	8,311	10,536	14,250	35.3

SOURCE: 1950-1970, Department of Commerce, Census Bureau; 1976 estimates by Arizona Department of Economic Security.

RECREATION. In the study area, demand for outdoor recreation opportunities has increased rapidly with increasing population. As a part of this demand there is a great need for water-based recreation opportunity. "The outdoor recreation demand in Arizona is considerably higher than in most other parts of the nation"<sup>12</sup> Demand is greatest for passive outdoor recreation (picnicking, sightseeing, attending outdoor events, pleasure walks, and nature walks) followed by active outdoor, water sports, and back-country recreation in decreasing order of demand. These State characteristics should be considered indicative of the study area due to its proximity and ease of access to the majority of Arizona's people. Pinal and neighboring Maricopa and Pima Counties combined have over 3/4 of the State's population. The Arizona Outdoor Recreation Plan has aggregated recreation supply and demand information for Pinal and Gila counties as Planning District V. Table 3, below, indicates the percent of needs met in 1970, and the percent of needs that will be met in 1980 and 1985 for several recreation activities in District V. These figures from the state plan take into account all existing and proposed recreation facilities provided from the Federal level to the local level of development.

TABLE 3  
RECREATION NEEDS FULFILLED

	<u>1970</u>	<u>1980</u>	<u>1985</u>
Picnicking	58%	49%	47%
Tennis	0%	0%	0%
Multiple Use Courts	5%	5%	4%
Camping	85%	66%	63%
Playing Fields	76%	67%	64%
Boating and Water Skiing	100%	100%	100%

SOURCE: Arizona State Wide Comprehensive Outdoor Recreation Plan

According to the Arizona Plan, the need for golf courses in Pinal County is also unsatisfied. Within District V, population and demand for recreation opportunity is generally concentrated in the study area whereas much of the supply is in or adjacent to Gila County. The imbalance in water-based recreation opportunity is shown below:

TABLE 4

## SUPPLY OF WATER BASE RECREATIONAL RESOURCES

	<u>Pinal Co.</u>	<u>Gila Co.</u>	<u>District V (Pinal &amp; Gila Counties)</u>
<u>Rivers and Streams Used for Recreation</u>			
Number of	1	16	17
Miles of	5	223	228
<u>Lakes and Reservoirs Used for Recreation</u>			
Number of	2	3	5
Acres of	6,560	15,098	21,658

SOURCE: Arizona Statewide Comprehensive Outdoor Recreation Plan.

Based on the above, unsatisfied needs in the study area are probably greater than in District V as a whole. Furthermore, the Arizona Plan listed as its Priority 1 Action "To develop outdoor recreation facilities in reasonable proximity to the large population centers of the State."<sup>13</sup> Future studies will further define recreation needs. A major revision of the Arizona Outdoor Recreation Plan is currently underway by the Arizona Outdoor Recreation Coordinating Commission and should be available in 1978. Aggregation of statistics by county in this revision will refine study area recreation analysis.

## Existing Flood Control Improvements

**TAT MOMOLIKOT DAM.** The completion of Tat Momolikot Dam in 1974 by the Corps of Engineers on the Papago Indian Reservation has provided flood control on the Santa Rosa Wash. This multipurpose project consists of a 12,500 foot rolled-earth embankment of maximum height 75.5 feet with a detached, fixed-crest, uncontrolled spillway. The dam, controlling flows from an area of 1,780 square miles has a design capacity at the spillway crest of 200,000 acre-feet. Of this, 40,000 are allocated to sediment storage; 15,000 to water conservation for use on the Indian Reservation; and 145,000 acre-feet to flood control storage. The dam and reservoir would reduce the standard project flood peak inflow of 77,000 cfs to about 5,000 cfs outflow. A general lack of precipitation since completion of the project has resulted in water being unavailable as intended, for Papago use.

**GREENE CANAL.** Greene Canal was built around the turn of the century to divert water from the Santa Cruz River mainstem to a reservoir built at Quajote Wash (subsequently known as Greene's Wash) for agricultural use downstream. The dam was sabotaged by local farmers and never rebuilt.

Greene's Canal continues to divert flows from the Santa Cruz to Greene's Wash. Gradually erosion along the upstream reach of the canal has increased the canal capacity, which has resulted in the diversion of nearly all flows from the Santa Cruz mainstem. As the flat areas north of the canal were developed, the canal became important for flood damage prevention. The north side of the canal has since been built up as a flood protection levee. Shortly after the 1962 flood, the Greene Reservoir Flood Control District was formed to maintain the north bank of the canal and build supplementary flood protection levees north of the canal. Since formation of the district, levees in the area have been damaged or breached in 1964, 1965, 1966, and 1967. Repair of these has been done with Federal funds under Public Law 99 authorization and at local expense. The downstream end of the canal was rebuilt in 1967 with a 3-mile improvement under the supervision of the Soil Conservation Service. These improvements have also suffered damage and been repaired. Over the past 10 years, through the Agricultural Conservation Program (administered by SCS) the Midway and Stanfield Flood Control Districts have constructed intermittent channels downstream to carry low-level floodflows to the Gila River. Levees on the Papago Reservation protect the village of Chuichu from frequent flooding.

#### Plans and Studies by Others

Local municipalities, irrigation districts, and Pinal County along with interested State and Federal agencies have prepared plans and studies for the study area. Formulation of alternative plans to meet this study's objectives must be consonant with those of others. Several reports are noted here, others will be found in Exhibit 4.

Pinal County. In 1967 Pinal County published the "Pinal County 1985 Development Plan" with Federal financial assistance from H.U.D. under Section 701 of the Housing Act of 1974.

Bureau of Reclamation. In July of 1976 the U.S. Bureau of Reclamation issued "San Pedro-Santa Cruz, Arizona; Concluding Report." The Bureau evaluated alternatives including storage at the Sasco site, just west of Redrock on the Santa Cruz mainstem, diversion of waters to Greene's Wash with storage near the Sawtooth Mountains, and a combination of these two plans. Diversion of Santa Cruz waters into the reservoir of Tat Momolikot Dam was also evaluated. Although, there was considerable local support for these plans, they were found to be economically unfeasible.

Department of Agriculture. The U.S. Department of Agriculture, in cooperation with the Arizona Water Commission, has prepared a draft report entitled "Santa Cruz-San Pedro River Basin, Arizona". Although the report is not yet available in final form, much information of value is referenced in this Plan of Study. The final report will be consulted in future studies.



## Projecting Future Conditions

Projection of future conditions is essential to the analysis of effects caused by alternative proposals. Projection of a "no-action" scenario establishes a base against which other proposals can be compared whether they be adverse or beneficial. Future economic activity in the study area will be based on population projections made by OBERS (Bureau of Economic Analysis-Department of Commerce/Economic Research Service - Department of Agriculture), DES (Arizona Department of Economic Security), and OEPAD (Arizona Office of Economic Planning and Development). DES and OEPAD are expected to reconcile their projections into an official State of Arizona projection this year. The DES and OEPAD projections for Pinal County, are as follows:

### Future Population of Pinal County

	<u>DES</u>	<u>OEPAD</u>
1970*	68,579	68,579
1976**	86,800	86,800
1980	97,200	97,700
1985	108,200	104,900
1990	114,000	112,600
2000	124,000	123,800

\* 1970 Census

\*\* 1976 Estimate by DES

When assumptions must be made about the allocation of population and changes in land use within the study area, some significant factors to be considered will be:

1. Past trends of local areas.
2. Projected demand for the major agricultural products of the area.
3. Projected demand for copper.
4. Cost and availability of ground water for all purposes.
5. Availability of C.A.P. (Central Arizona Project) water for all uses.
6. Projected growth of the Phoenix and Tucson metropolitan areas.

## Establishing Planning Objectives

Planning objectives for this study are the water and related land-resource management needs specific to the lower Santa Cruz area which can be addressed to enhance national economic development and environmental quality.<sup>14</sup> Objectives for plans formulated during this study include:

- a. Flood damage reduction.
- b. Wise use and conservation of surface and ground water resources.
- c. Increased water-related recreation opportunities.
- d. Protection, enhancement or creation of areas of natural beauty and human enjoyment.
- e. Preservation or enhancement of valuable archeological, historical, biological, and geological resources, and ecological systems.
- f. Enhancement of water, land, and air environmental quality.

## II. FORMULATION OF ALTERNATIVES

Alternative plans consisting of resource management measures singly or in combination will be formulated to address the planning objectives. The plans and measures which have been identified to date include:

a. No Action. A decision of "no action" will do nothing to alleviate the existing flood hazard or other problems and needs in the study area. The "no action" plan will, however, serve as a base condition against which other plans can be compared.

b. Diversion. A diversion of floodflows from the Santa Cruz River in the vicinity of Red Rock into Lake St. Clair (on the Santa Rosa Wash at Tat Momolikot Dam) has been proposed by local interests. This alternative would directly impact and require the cooperation of the Papago Indian Reservation as well as other land owners in the vicinity of the diversion. It may increase the availability of water on the Reservation for all purposes; however, it may require modification of the dam.

c. Upstream Storage on the Santa Cruz River and Tributaries. If suitable storage sites are available, storage of floodflows would lessen the flood hazard in the study area. Upstream storage may offer potential for several purposes including water conservation and recreation as well as flood control.

d. Channelization. Straightening and enlarging of existing streambeds and channels in the study area would increase discharge capacity and thereby decrease flood damages.

e. Localized Protection. A measure effective for small areas with high flood damage potential is protection by levee.

f. Flood Plain Management. Management of flood-prone areas to preclude certain types of highly damageable development will limit increases in future flood damages. Such management can do little to change present use of land and, therefore, little to prevent damage to the extensive agriculture and limited urban development presently in the flood plain.

g. Floodproofing. In certain situations, alteration of existing structures can prevent future damages. Use of floodproofing in the lower Santa Cruz area may be limited to isolated buildings of high value.

h. Flood Hazard Warning. A system of floodwarning may eliminate hazard to human life and damage to moveable or easily protected property.

i. Flood Plain Evacuation. Permanent evacuation of flood-prone areas would eliminate flood damages. This alternative induces severe hardship on present occupants of the flood plain and results, generally, in decreases to regional and national economic development but is often environmentally beneficial.

### III. IMPACT ASSESSMENT

DETERMINING SOURCES OF IMPACT. Each alternative with its component measures will be analyzed to determine potential impacts. Particular attention will be given to identifying and describing specific sources of impact.

IDENTIFYING AND TRACING IMPACTS. For each alternative plan, comparison will be made between its inputs and outputs and the base condition to determine whether a change in any of the base conditions can be forecast as caused by the plan. Each cause will be traced to determine all of its significant effects.

SPECIFYING INCIDENCE AND MEASURING IMPACTS. The location, timing, duration, and magnitude of each significant impact will be determined.

#### IV. EVALUATION

APPRAISING PLANNING OBJECTIVE FULFILLMENT. The first evaluation activity is to compare the impacts of alternative plans to the planning objectives. The next activity is to determine the extent to which alternatives satisfy these objectives, comparing the impacts of the plans and making a subjective judgment about the degree of satisfaction. Subjective judgments must reflect both professional analysis and public perceptions about how well the planning objectives are addressed. In subsequent iterations, objectives would be recast or measures altered to more fully satisfy objectives.

APPRAISING SYSTEM OF ACCOUNTS CONTRIBUTIONS. The significant impacts of each plan will be evaluated to establish the plan's contributions to the National Economic Development, Environmental Quality, Regional Development, and Social Well Being accounts of the Principles and Standards. In general, the process used in appraising planning objective fulfillment will be repeated to accomplish this evaluation. Identifying contributions to the four accounts involves a wide range of uncertainties which will be specified quantitatively or qualitatively, including who gains or loses, locational incidence, and time of occurrence. Because they are especially critical to the efficiency of each plan, unintended contributions will also be identified. If the unintended contribution is significantly beneficial, it suggests the existence of previously unidentified concerns that a reformulation may address more fully. If the unintended contribution is significantly adverse, further reformulation will also be necessary.

APPLYING SPECIFIED EVALUATION CRITERIA. The third evaluation activity involves applying specified criteria to each alternative plan to test plan responsiveness. These criteria are: acceptability, completeness, effectiveness, and efficiency, as explicitly stated in the Principles and Standards; uncertainty, geographic scope, National Economic Development, benefit-cost ratio, and reversibility, are derived from the first four.

PERFORMING TRADE-OFF ANALYSIS. Subsequent to identifying the contributions of alternative plans to planning objectives and the System Accounts and establishing plan response to specific evaluation criteria, trade-off analysis will be conducted to analyze the comparative contributions of alternative plans. When this has been completed for each alternative, the results will be compiled so that what is gained or foregone by choosing a given alternative over another is clearly stated.

DESIGNATING NED AND EQ PLANS. The alternatives which appear to best meet the criteria for the NED and EQ plans (as stated in ER 1105-2-230) will be designated as a basis for subsequent iteration. This requires analyzing the overall economic and environmental contributions of each alternative when compared with the no action plan. The alternatives with the greatest environmental contributions will be candidates for EQ plans. The designation of NED plans can be made largely by drawing upon analysis of the economic returns to each alternative. The designation of EQ plans is highly subjective



and must reflect societal preferences for the environmental contributions of the alternative plans. Particular note will be taken that a NED plan and an EQ plan could be similar in certain instances where both sets of criteria are met by the same measures.

## V. THE STUDY

### Scope

GENERAL. The estimated total cost of Survey Report studies is \$700,000. The components of this cost are displayed in Exhibit 3 and discussed here.

PRELIMINARY PLANNING. Total cost for preliminary planning is estimated at \$93,300. Activities include preparation of the Plan of Study, preparation for public meetings, preparation of public brochures, and workshop coordination.

HYDROLOGY STUDIES. Hydrologic studies will cost \$51,800. Studies will include:

- a. Determination of the area's meteorological and hydrological characteristics.
- b. Determination of flood characteristics, frequencies and overflow areas within the study area.
- c. Correlation of floods affecting the study area along the Santa Cruz River mainstem with those in the Santa Rosa basin. This analysis is necessary for formulation and evaluation of the diversion alternative.
- d. Evaluation of other alternatives, including the impact on downstream areas resulting from upstream diversion and storage.

SURVEY AND MAPPING. The in-house cost of these studies is \$3,700. This will include surveys as necessary to develop adequate base data for plan formulation. Other general topographic surveys in the vicinity of Greene's Canal by the U.S. Geological Survey are underway on an accelerated schedule. The plan formulation is scheduled to use new U.S.G.S. topographic data for the areas covered by the Red Rock, Eloy, Silver Reef Mountains, and Antelope Peak 15' quadrants as they become available in the Spring of 1978.

FOUNDATION AND MATERIALS STUDIES. These studies will cost \$16,400. The studies anticipated are those needed to determine general project feasibility and include:

- a. Examination of existing soils and borings information.
- b. Exploratory test borings.
- c. Seismicity.

DESIGN AND COST ESTIMATE. The total amount allocated to this item is \$88,100. Of this, hydraulic design for structural alternatives of diversion, storage, channelization and local protection will cost \$33,600. Quantity and cost estimates for these alternatives will require \$54,500.

ECONOMIC STUDIES. Total costs for economic studies are estimated to be \$40,900. These studies consist of:

- a. Evaluation of existing and projected property values subject to flooding.
- b. Estimate of the benefits accruing to alternative plans. Anticipated benefits include flood damage reduction, savings in cost of fill, recreation and water conservation.
- c. Estimate of socio-economic impacts of alternative plans.
- d. Computation of annual charges, average annual benefits, and benefit-cost ratios.

REAL ESTATE. Total costs for real estate activities are expected to be \$5,200. Preliminary cost of rights-of-way, damages and relocations for the various plans will be a part of the determination of general project feasibility.

SPECIAL STUDIES. The estimated costs for special studies is \$120,200. Those which are anticipated are described here:

a. Economic Base Studies. Studies to determine the economic base conditions are estimated to cost \$24,200. These studies will include an evaluation of the existing economic base and an evaluation of the most probable and other, alternative futures for the study area. Employment, income, and population will be the basic economic indicators.

b. Environmental Studies. The estimate of environmental study costs for this survey report are \$36,700. An environmental assessment and impact statement will be prepared to provide input to the formulation of alternative plans for the survey report. The necessary work will be done in three "phases."

- (1) Inventory: Collect data to determine the environmental setting.
- (2) Plan Formulation: Develop alternative plans of action.
- (3) Effects Assessment: Determine the environmental impacts of each alternative.

During the period designated as inventory, data will be collected to describe the present environmental setting of the study area. Many subjects will be investigated during this period. Among them are:

Physical setting	Air quality
Climate	Natural habitats, endangered species
Hydrology	Recreation
Geology	Socioeconomics, demographics
Seismicity	Cultural, historical, and archeological
Ground water	resources
Mineral resources	Public services, infrastructure
Water quality	Aesthetics

c. Fish and Wildlife Coordination. The U.S. Fish and Wildlife Service will provide input and a report of the impact on the wildlife resources within the study area. The cost of their input and report is estimated to be \$7,500.

d. Water Rights Investigation. The cost of this investigation is estimated to be \$12,000. It will include the determination of claims to surface waters affected by alternative plans. The effects of those plans on water rights holders will be established to provide an input to the evaluation of alternatives.

e. Recreation. The cost of recreation studies is estimated to be \$26,100. These will include preliminary design of recreation facilities for those feasible alternatives which can accommodate recreation development. Analysis of recreation benefits will also be a part of these studies.

f. Percolation/Ground Water Recharge. This study, estimated at \$7,500, will evaluate the impact various alternative plans will have on the lower Santa Cruz ground water basin.

g. Archeological Studies. Those studies required for Survey Report preparation have been completed at a cost of \$6,200. They are discussed within this Plan of Study.

PREPARATION OF REPORT AND PROJECT MANAGEMENT. Report preparation and project management is estimated to cost \$149,700. This activity includes coordination with local officials, writing, editing, and reproduction of reports, management of ongoing study efforts, and preparation of briefings, and congressional data.

#### Plan Development Stages

The objectives of this investigation will be accomplished in three stages. The initial stage involves the development of this plan of study as a guide to subsequent planning. The intermediate stage is concerned with identifying a broad range of alternatives for achieving the objectives and developing and

analyzing the alternatives in enough detail to assess and evaluate their potential impact. The final stage involves screening the plans and developing detail as a basis for selection and recommendation.

During intermediate and final stage studies, emphasis will be placed on the achievement of National Economic Development (NED) and Environmental Quality (EQ) as co-equal national objectives. The NED plan will be that which best achieves an increase in the value of the nation's output of goods and services and improves national economic efficiency. The EQ plan will be that which will contribute the most to the enhancement of the environmental qualities of the region. All alternatives will be evaluated on the basis of their impacts on the economic, social, environmental, and human well-being in the study area, in accordance with the latest Corps policy for Planning Water and Related Land Resources on implementation of Water Resources Council Principles and Standards.

The initial and intermediate study stages will consist of review of existing economic, environmental, engineering, and geological data, as well as conducting a series of studies to establish the base condition, with component elements, to predict the most probable future (no-action condition) and develop intermediate plans. These studies will determine the preliminary feasibility of each alternative plan. At the Checkpoint I Conference, the study progress and results will be evaluated, preliminary study results revealed, and detailed study matters discussed to facilitate decisions on study direction.

During the final stage of the study, detailed plans will be developed and evaluated and the formulation stage public meeting will be held. At the same time, the report appendices and the EIS will be prepared.

After the Checkpoint II Conference, completing the recommended plan, writing the final report, and reviewing by SPL and SPD are scheduled.

#### Public Participation

**PUBLIC MEETINGS.** Coordination of this study with individuals and private groups is being carried out formally through public meetings. Public meetings are held to:

- Inform the public about studies underway.
- Give all interested persons an opportunity to publicly and fully express their views concerning such studies.
- Obtain information which will assist those involved in arriving at sound conclusions and recommendations.
- Contribute to interagency coordination.

An initial public meeting was held in Casa Grande on 16 June 1976. Its purpose was to explain the nature and scope of the study; to open lines of communication; to listen to the views of the public on problems, needs, and desires; and to identify interested individuals and agencies. The registered audience at this public meeting was 46. Representatives of the Maricopa, Stanfield, Midway, and Greene Reservoir Flood Control Districts and communities in the study area, as well as residents in the area, emphasized the need for flood control and recommended a plan for the diversion of Santa Cruz River floodflows to Tat Momolikot Dam on Santa Rosa Wash. A representative of the Buckeye Water Conservation and Drainage District (the district diverts water downstream of the study area for irrigation purposes) suggested that a study of water rights be made, especially when diversions are being considered. Correspondence from the Arizona Land Department also suggested the need for water rights investigations. A representative of the Arizona Wildlife Federation objected to the diversion plan and any other flood control program, as such works would affect wildlife habitat and greenbelt areas along the Santa Cruz River. Similar comment was received in letters from the Sierra Club and the Audubon Society. Representatives from the Bureau of Indian Affairs emphasized the necessity for considering the problems and needs of the Papago Indian Reservation.

A formulation-stage meeting will be held when all alternative solutions are reasonably known, after the completion of preliminary studies but before a plan has been tentatively selected. A late-stage meeting will be held after detailed studies but before study completion to present the findings of the detailed studies, including the rationale for any solution to be proposed, and the tentative recommendations of the reporting officer.

**PUBLIC PARTICIPATION GROUP.** A citizen's advisory committee will be formed consisting of local citizens and others interested in the study. This committee will participate in a series of informal workshops. Involvement of a diverse group with varied concerns including those most directly affected by alternative plans such as representatives of the local flood control districts, the Indian reservations and environmental groups will assure balanced, ongoing, public input to the study.

**PUBLIC BROCHURES.** Before the formulation stage public meeting a public brochure will be developed based on prior workshop meetings. Information will include introduction, alternative plans developed, and discussion on impact assessment of each plan. A public brochure will also be prepared before the late stage public meeting.

**LIST OF AGENCIES, GROUPS.** For this study the agencies and groups whose cooperation and comments will be requested are shown here.

#### FEDERAL AGENCIES

Bureau of Reclamation, USDI  
Bureau of Outdoor Recreation, USDI  
Geological Survey, USDI  
National Oceanic and Atmospheric Administration, USDC

## FEDERAL AGENCIES (Continued)

Environmental Protection Agency  
Federal Power Commission  
National Park Service, USDI  
Geological Survey, USDI  
U.S. Fish and Wildlife Service, USDI  
Federal Highway Administration, USDT  
Public Health Service, USDHEW  
Bureau of Indian Affairs, USDI  
Bureau of Land Management, USDI  
Bureau of Mines, USDI  
National Weather Service, USDC  
Bureau of the Census, USDC  
Soil Conservation Service, USDA

## NON-FEDERAL AGENCIES, GROUPS

Arizona Office of Economic Planning and Development  
Arizona Game and Fish Department  
Governor's Commission on Arizona Environment  
Arizona Water Quality Control Council  
Arizona State Land Department  
Arizona Outdoor Recreation Coordinating Commission  
Arizona Department of Transportation  
Arizona Water Commission  
Arizona Department of Economic Security  
Arizona Department of Health Services, Bureau of Water Quality Control  
Arizona Bureau of Mines  
Arizona State Museum  
Arizona State Parks  
Arizona State University  
University of Arizona  
Pinal County  
City of Eloy  
City of Casa Grande  
Arizona City  
Central Arizona Association of Governments  
Papago Indian Reservation  
Maricopa Ak Chin Indian Community  
Gila River Indian Reservation  
Greene Reservoir Flood Control District  
Midway Flood Control District  
Stanfield Flood Control District  
Maricopa Flood Control District  
Central Arizona Irrigation and Drainage District

# NON-FEDERAL AGENCIES, GROUPS (Continued)

Silver Bell Irrigation and Drainage District  
Hohokam Irrigation and Drainage District  
Maricopa-Stanfield Irrigation and Drainage District  
San Carlos Irrigation and Drainage District  
Audubon Society  
Sierra Club  
Southern Arizona Environmental Council  
Southern Arizona Sportsmen's Association  
Arizona Wildlife Federation

## Milestone Schedule

No.	Title	Approved Date	Proposed Date
2	Approved Plan of Study	Sep 77	Sep 77
3	Submit Phase I Study Report	Indef	Jun 79
4	Checkpoint I Conference	Indef	Apr 80
5	Formulation Stage Public Meeting	Indef	Jun 80
6	Checkpoint II Conference	Indef	Oct 80
7	Submit District Draft	Indef	Apr 81
8	SPD Review Draft Report	Indef	Jun 81
9	Late Stage Public Meeting	Indef	Oct 81
10	Submit Final Report	Indef	Dec 81
-	Scheduled Completion	Indef	Feb 82

## Estimate of Study Costs

The total cost of the investigation is now estimated at \$700,000. Major elements of the study are shown on the accompanying PB-6, Exhibit 3. Prior to FY 1978 \$110,000 has been allocated.

Execution of the schedule requires that future funding conform to the following schedule which is based on full capability after FY 78. Fifty thousand dollars has been allocated for FY 78.

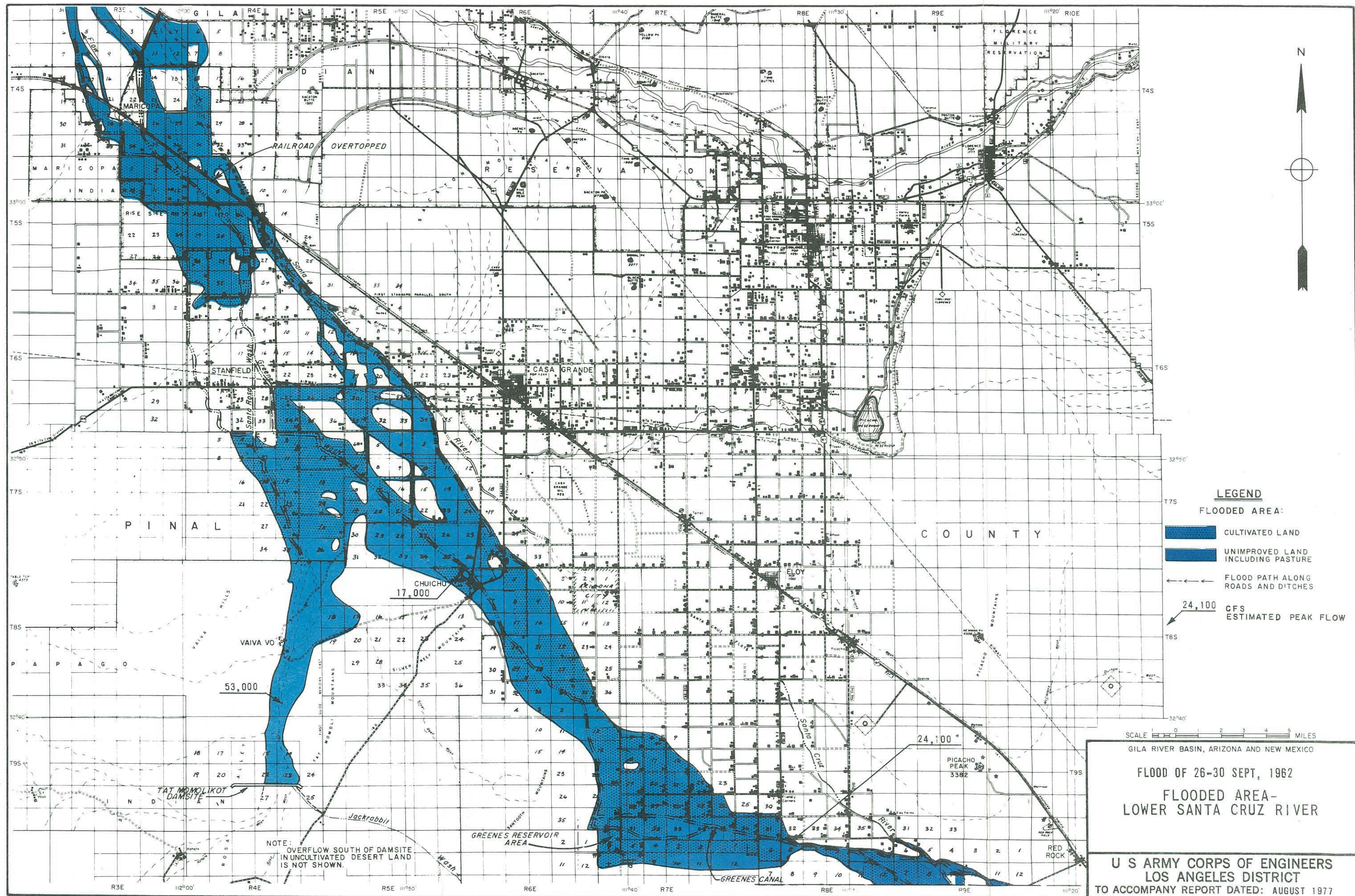
FY 79	\$175,000
FY 80	\$240,000
FY 81	\$105,000
FY 82	\$20,000



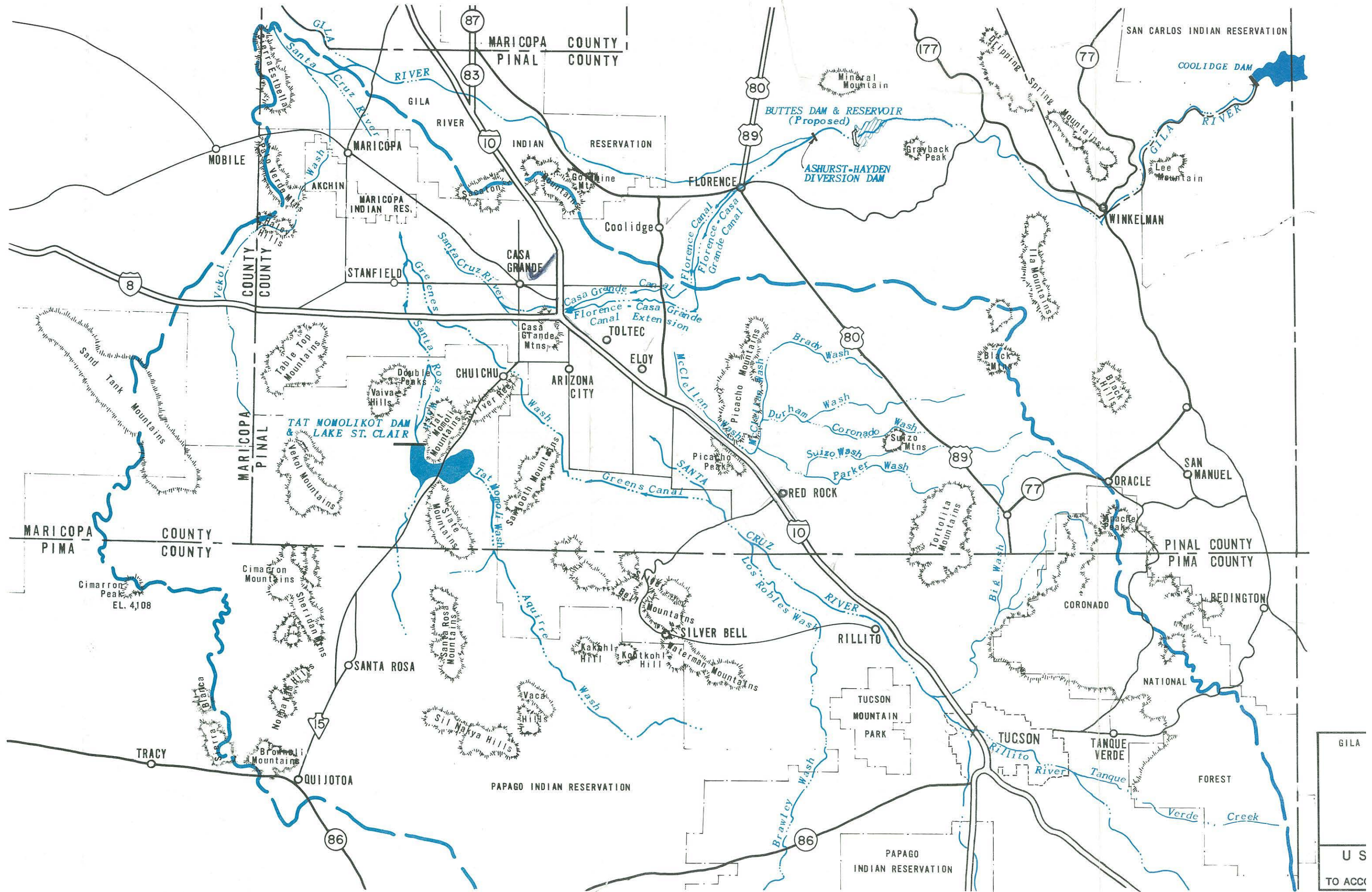
#### Recommendation

It is recommended that this Plan of Study be approved as a guide for completing the proposed interim survey report.

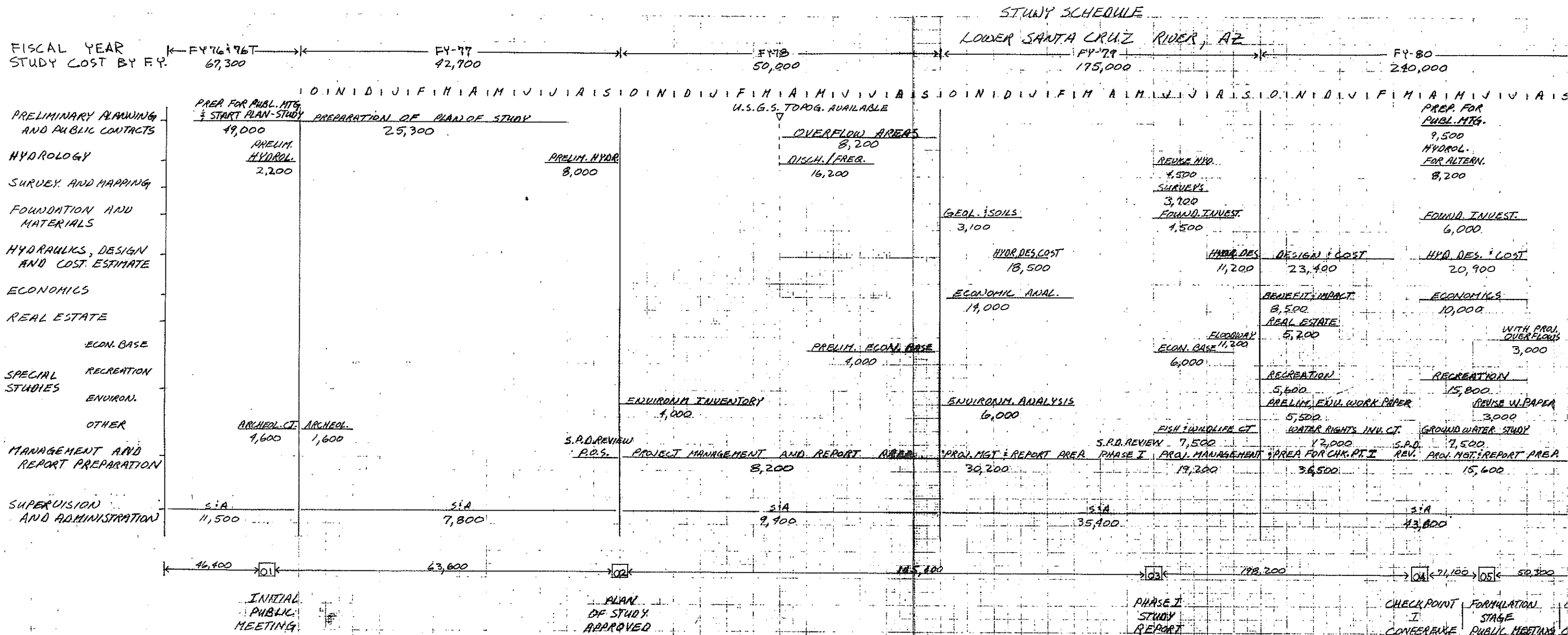


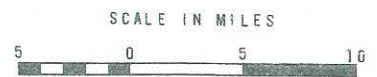
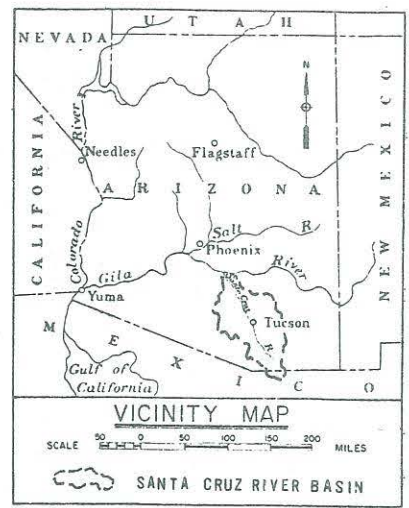
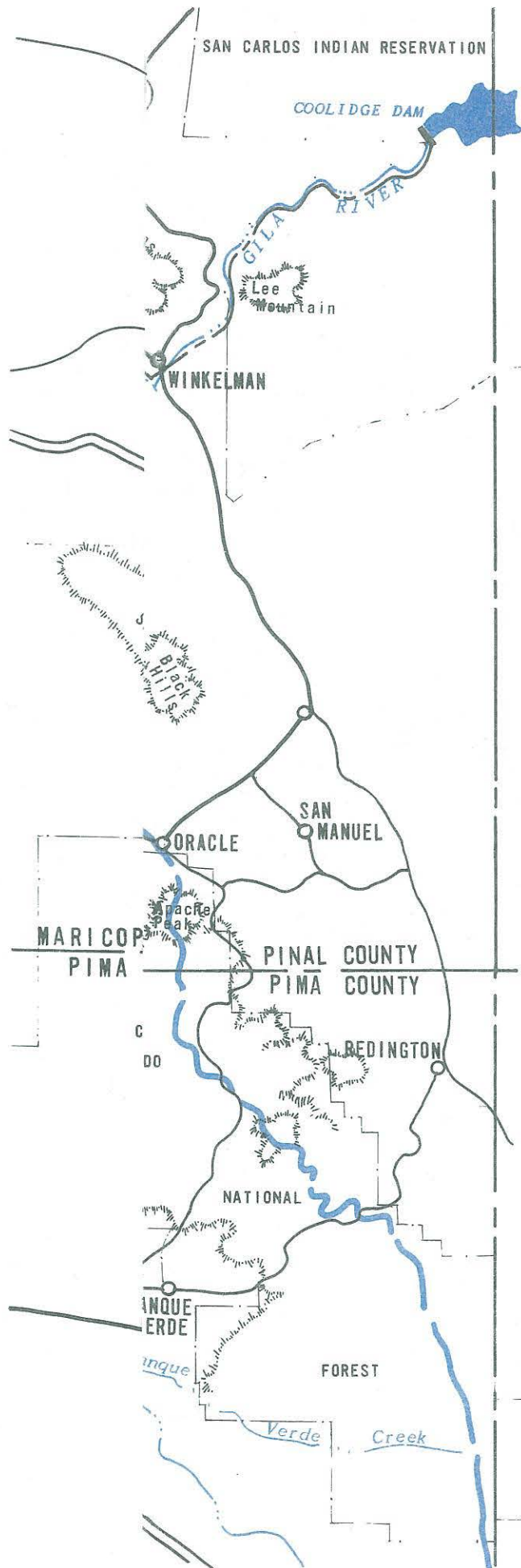












GILA RIVER BASIN, ARIZONA AND NEW MEXICO

STUDY AREA MAP

U S ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT  
TO ACCOMPANY REPORT DATED: AUGUST 1977

FISC FY-80  
STUD 240,000

FY-81  
105,000

FY-82  
20,000

ADMINISTRATIVE DIVISION ADMINISTRATIVE DIVISION

PREL AN.	PREP. FOR PUBL. MTG. 9,500		PREP. FOR PUBLIC MTG. 9,500	
HYD1 SURL	HYDROL. FOR ALTERN. 8,200	HYDROLOGY 4,500		
FOUN MA.	FOUND. INVEST. 6,000	FOUND. INVEST. 1,600	FOUND. INV. 1,200	
HYD1 ANL	HYDR. DES. & COST 20,900	HYDR. DES. & COST 8,900	HYDR. DES. 2,200	COST 3,000
ECON REA.	ECONOMICS 10,000	ECONOMICS 6,000	ECONOMICS 2,400	
	WITH PROJ. OVERFLOWS 3,000			
SPECI STUD.	RECREATION 15,800	RECREATION 1,000	RECREATION 700	REVISE EIS 2,000
	REVISE W. PAPER 3,000	DRAFT E.I.S. 8,900	REVISE D.E.I.S. 7,300	
CT.	GROUNDWATER STUDY 2,500			
MANU REV.	PROJ. MGT. & REPORT PREP 15,600	PROJ. MGT. & REPORT PREP 28,700	S.P.D. REVIEW DRAFT	REPORT S.P.D. REVIEW PREP FINAL 14,000
SUPE AN	SIA 43,800		SIA 18,100	SIA 3,700

04 74,180 05 50,300 06 73,200 07 7,600 08 25,200 09 2,000 10 0 11

CHECKPOINT I CONFERENCE FORMULATION STAGE PUBLIC MEETING CONFERENCE CHK PT II DISTRICT DRAFT REPORT FINISH DIVISION REVIEW LATE STAGE PUBLIC MEETING DISTRICT FINAL REPORT DIVISION ENGINEER NOTICE

STUDY SCHEDULE  
EXHIBIT 2